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(54) **INVERTER DEVICE, MOTOR, AND MOTOR UNIT**

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(57) **ABSTRACT**

An inverter device capable of suppressing generation of vibration and a puddle in a top wall of an inverter case is provided. The inverter device includes an inverter and the inverter case that accommodates the inverter inside the inverter case. The inverter case has a top wall covering the inverter from above. The top wall has a first inclined surface descending from a top part on the upper surface of the top wall toward a first end part of the top wall, and a plurality of first rod-shaped ribs extending from the top part toward the first end part. The first rod-shaped rib has a site in which a protrusion height from the inclined surface increases toward the first end part.

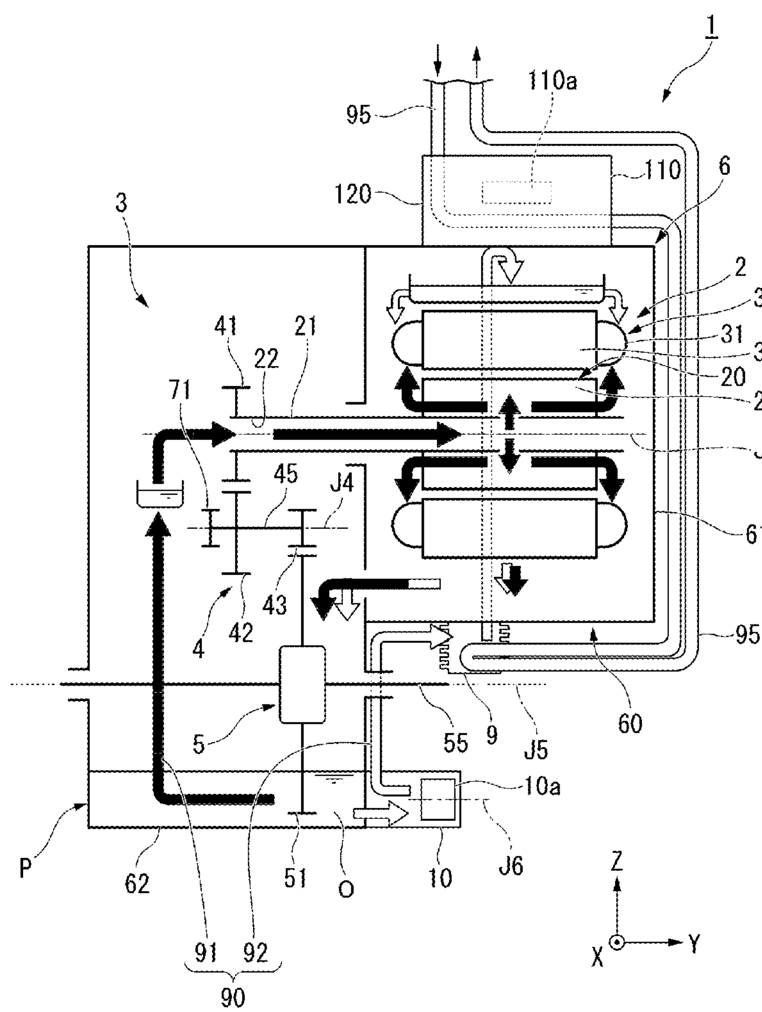
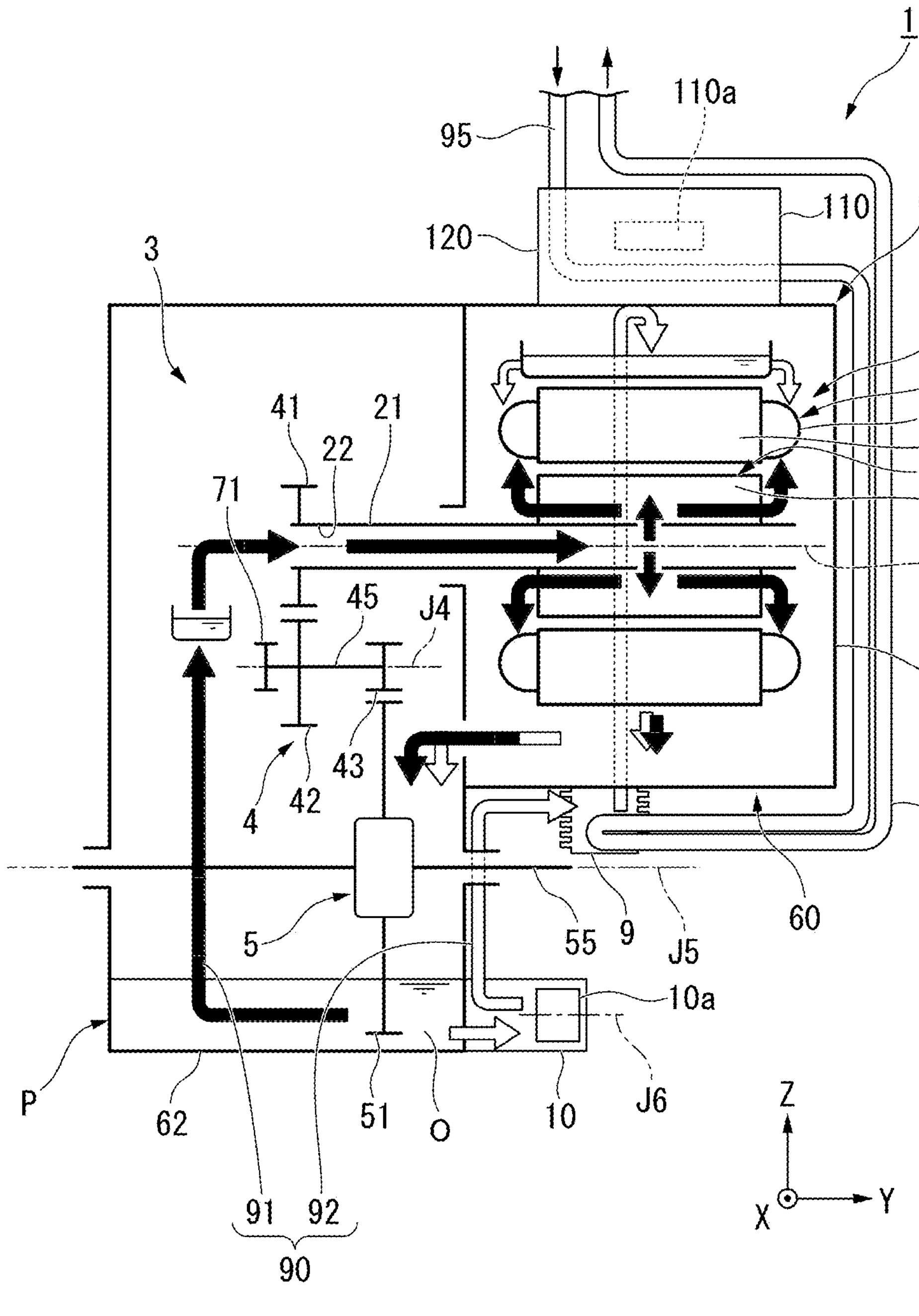


Fig. 1


1
95
110a
110
120
6
3
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31
32
20
24
41
21
22
71
J2
45
J4
61
43
42
4
95
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92
90
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X
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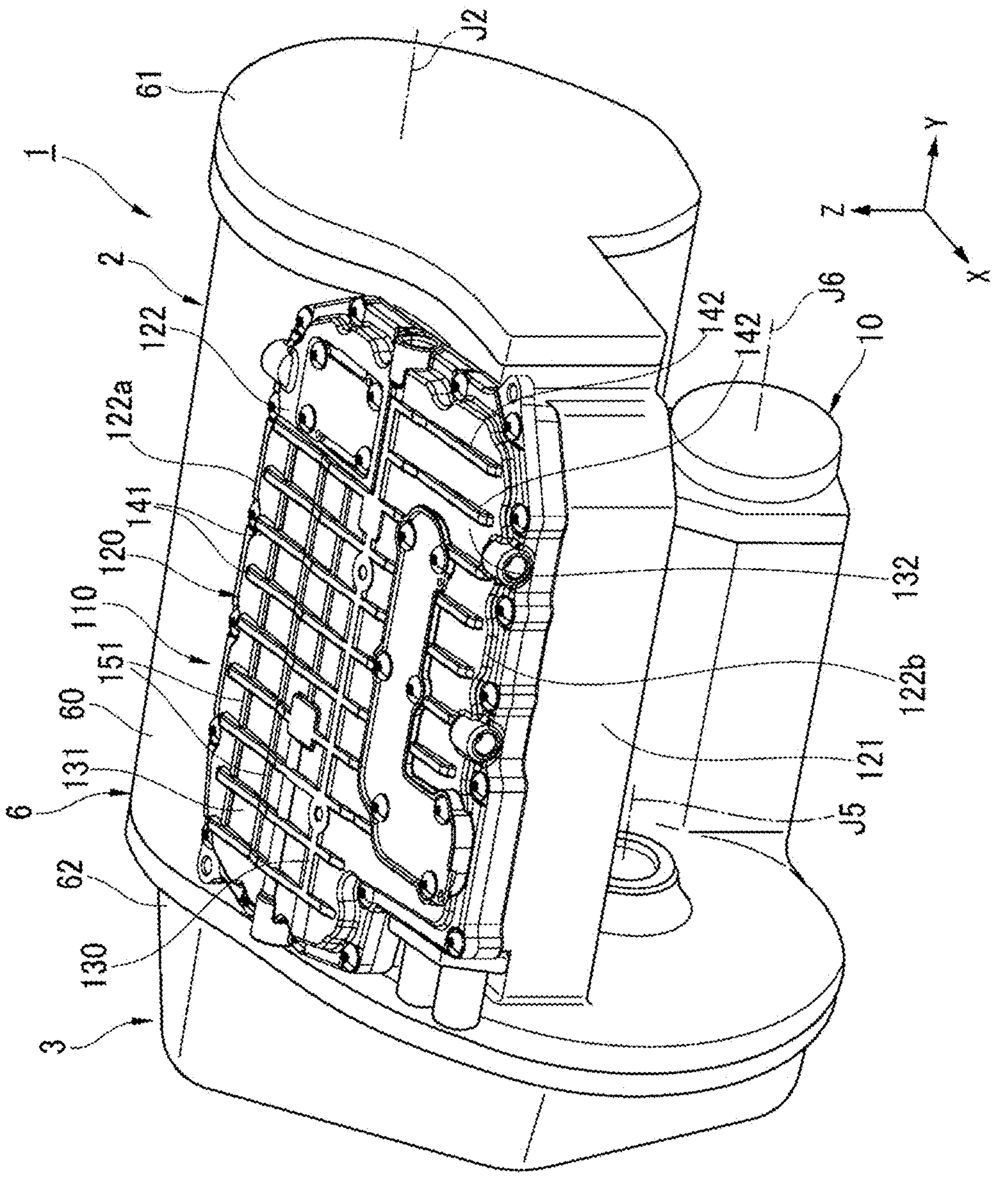
1
2
3
6
10
60
61
62
110
120
121
122
122a
122b
130
131
132
141
142
151
J2
J5
J6
X
Y
Z

Fig. 2

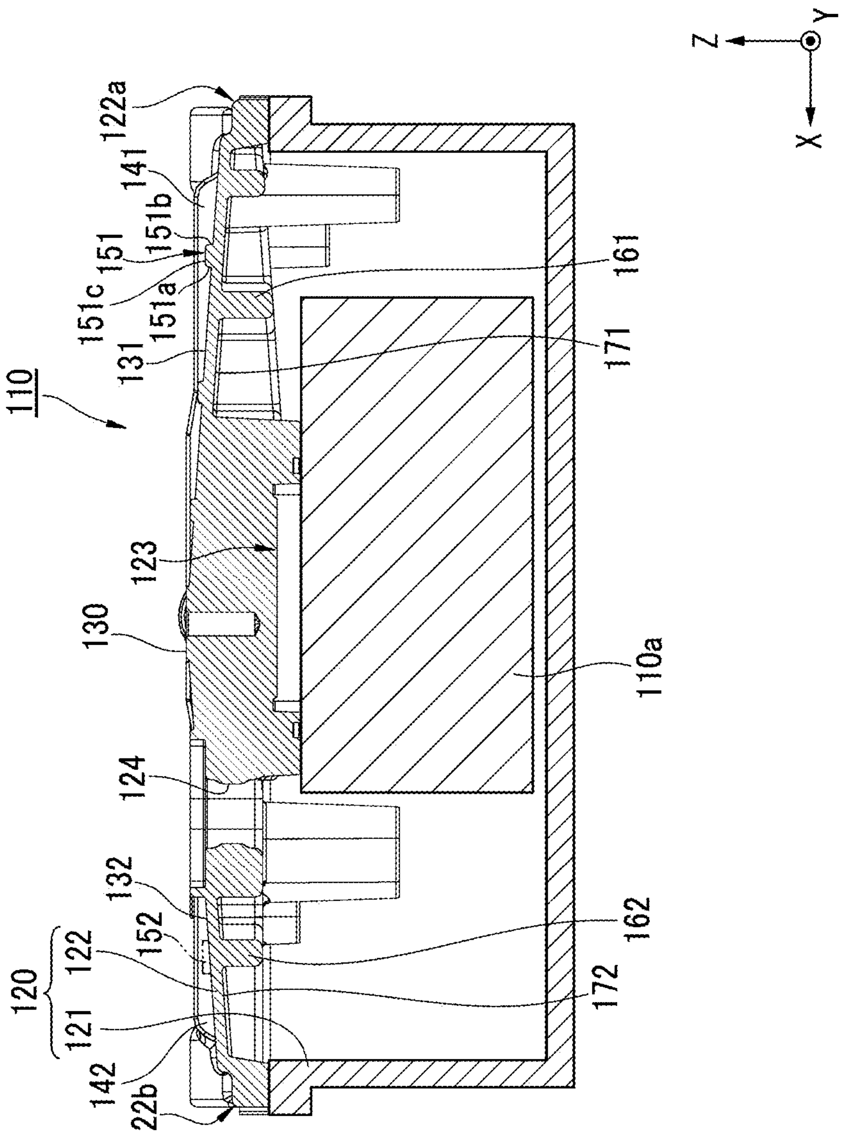
110
122a
141
151b
151
151c
151a
131
161
171
123
130
110a
124
132
152
122
120
121
142
122b
162
172
Z
Y
X

Fig. 3

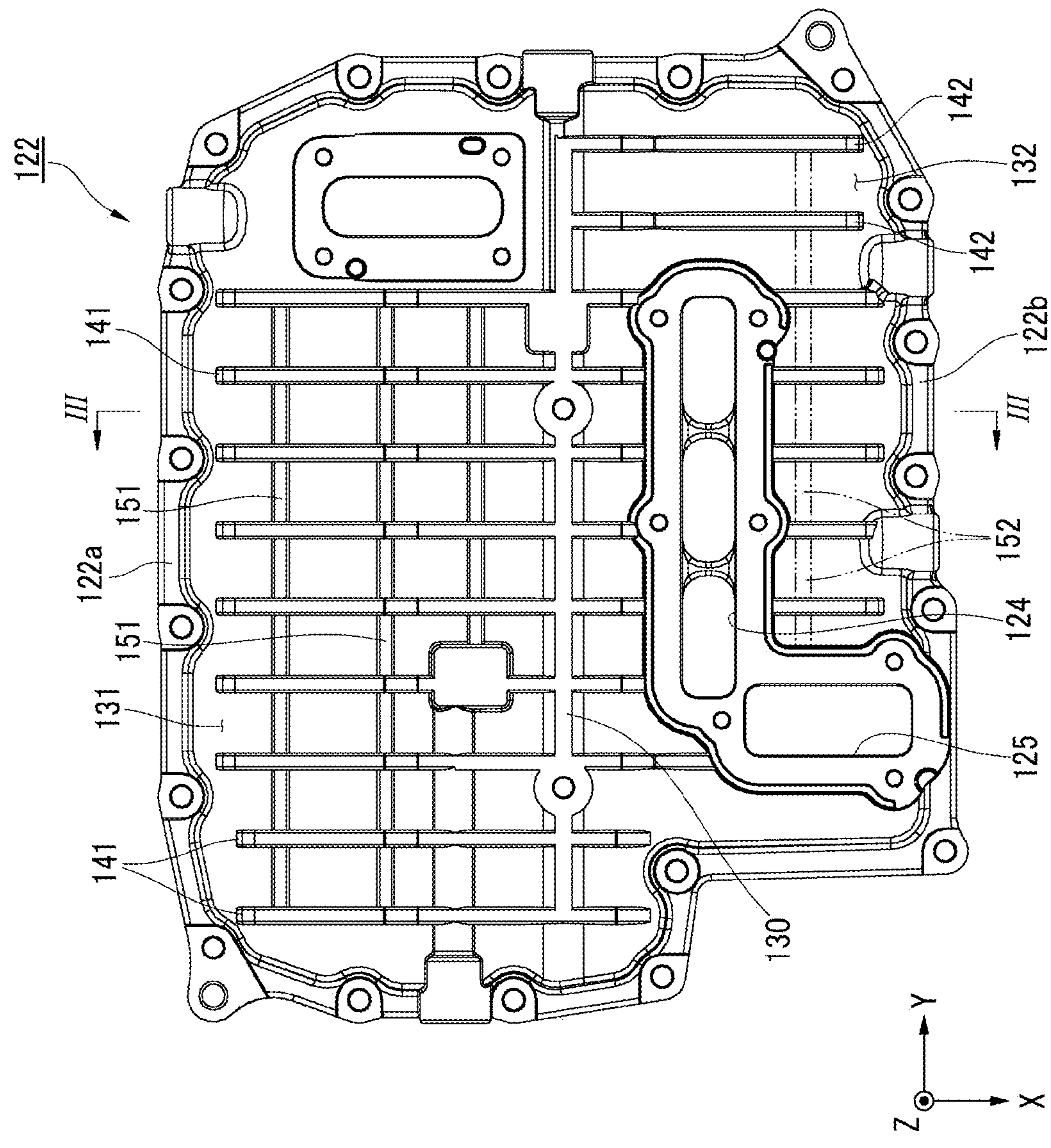
122
142
132
142
141
122b
III
III
151
152
122a
124
151
131
125
141
130
Y
X
Z

Fig. 4

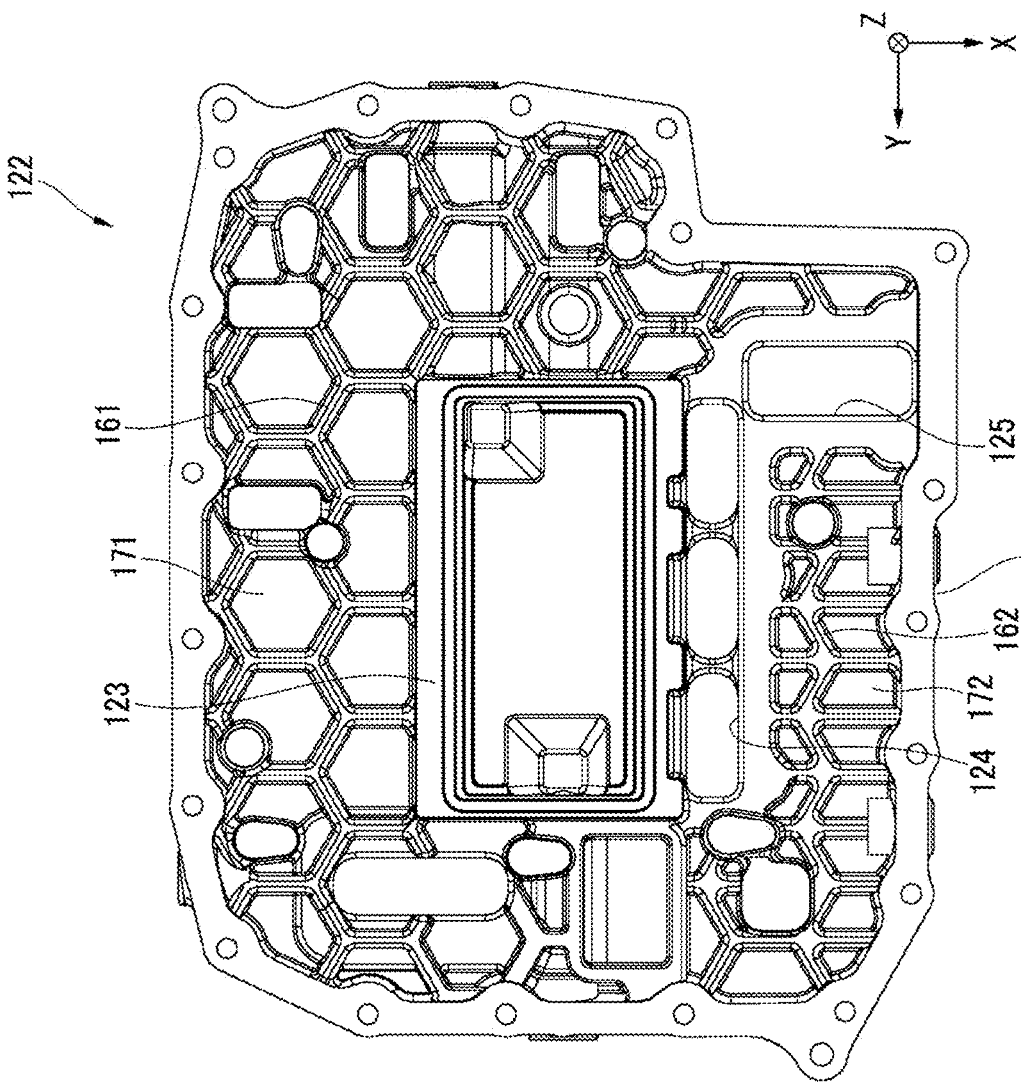

Fig. 5

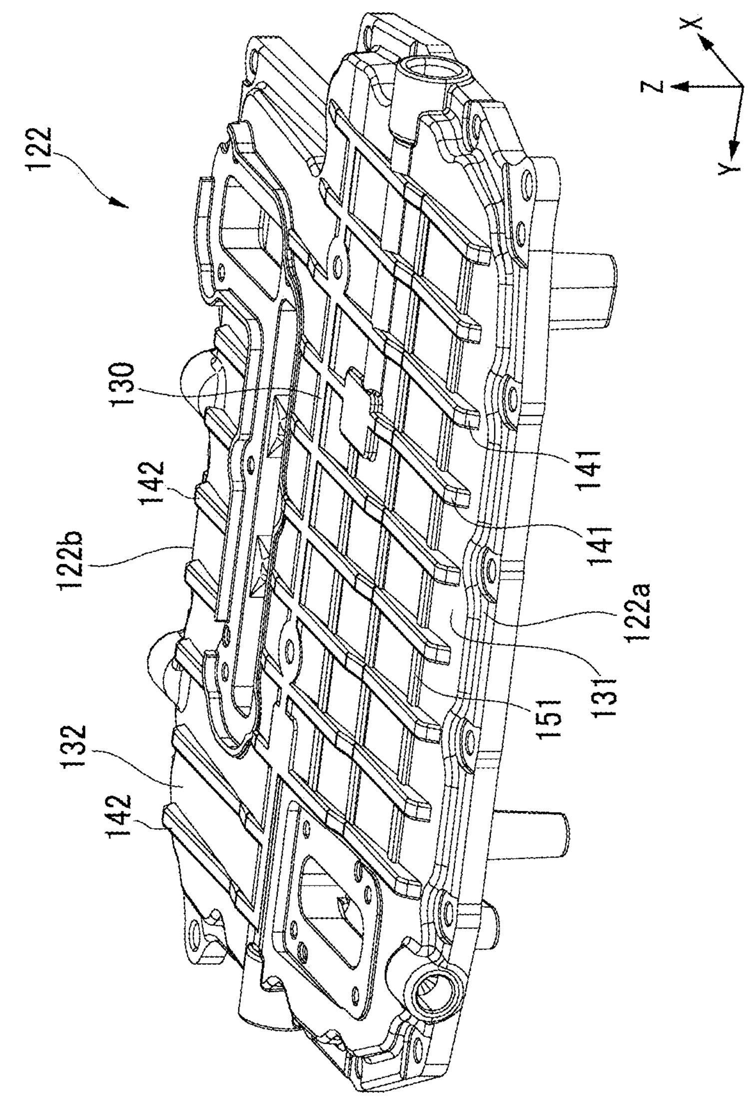

Fig. 6

INVERTER DEVICE, MOTOR, AND MOTOR UNIT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This is the U.S. national stage of application No. PCT/JP2020/034639, filed on Sep. 14, 2020, and priority under 35 U.S.C. § 119 (a) and 35 U.S.C. § 365(b) is claimed from Japanese Patent Application No. 2020-023048, filed on Feb. 14, 2020.

FIELD OF THE INVENTION

[0002] The present invention relates to an inverter device, a motor, and a motor unit.

BACKGROUND

[0003] In an electronic control device mounted on a vehicle or the like, a configuration in which a honeycomb-shaped rib is included in a part of a case that accommodates a circuit board is known.

[0004] In a motor unit having a structure in which an inverter case accommodating an inverter is continuous to a motor housing accommodating a motor, membrane resonance of the inverter case is liable to be excited by motor vibration generated when the motor is driven. Installation of a rib is effective for suppressing membrane resonance. However, when a closed annular rib in such as a honeycomb shape is arranged on the upper surface of the inverter case, water having entered a recess surrounded by the rib is less likely to be discharged.

SUMMARY

[0005] According to one exemplary aspect of the present invention, there is provided an inverter device including an inverter and an inverter case that accommodates the inverter inside the inverter case. The inverter case has a top wall covering the inverter from above. The top wall includes a first inclined surface descending from a top part on an upper surface of the top wall toward a first end part of the top wall, and a plurality of first rod-shaped ribs extending from the top part toward the first end part. The first rod-shaped rib has a site where a protrusion height from the inclined surface increases toward the first end part.

[0006] The above and other elements, features, steps, characteristics and advantages of the present disclosure will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a schematic configuration view of a motor unit according to an embodiment;

[0008] FIG. **2** is a perspective view of the motor unit according to the embodiment;

[0009] FIG. **3** is a schematic cross-sectional view of an inverter device according to the embodiment;

[0010] FIG. **4** is a plan view of an inverter cover according to the embodiment as viewed from above;

[0011] FIG. **5** is a plan view of the inverter cover according to the embodiment as viewed from below; and

[0012] FIG. **6** is a perspective view of the inverter cover according to the embodiment.

DETAILED DESCRIPTION

[0013] The following description will be made with the direction of gravity being defined on the basis of positional relationships in the case where a motor unit **1** is mounted in a vehicle on a horizontal road surface. In the drawings, an XYZ coordinate system is shown appropriately as a three-dimensional orthogonal coordinate system. In the XYZ coordinate system, a Z-axis direction corresponds to a vertical direction (i.e., an up-down direction), and a +Z direction points upward (i.e., in a direction opposite to the direction of gravity), while a −Z direction points downward (i.e., in the direction of gravity). An X-axis direction corresponds to a front-rear direction of the vehicle in which the motor unit **1** is mounted, and is a direction orthogonal to the Z-axis direction, and a +X direction points forward of the vehicle, while a −X direction points rearward of the vehicle.

[0014] However, the +X direction and the −X direction may point rearward and forward, respectively, of the vehicle. A Y-axis direction is a direction orthogonal to both the X-axis direction and the Z-axis direction and indicates a width direction (left-right direction) of the vehicle, and a +Y direction points leftward of the vehicle, while a −Y direction points rightward of the vehicle. However, when the +X direction points rearward of the vehicle, the +Y direction may point rightward of the vehicle, and the −Y direction may point leftward of the vehicle. That is, the +Y direction simply points to one side in the left-right direction of the vehicle, and the −Y direction points to the other side in the left-right direction of the vehicle, regardless of the direction of the X-axis.

[0015] In description below, unless otherwise specified, a direction (that is, the Y-axis direction) parallel to a motor axis J**2** of a motor **2** will be simply referred to by the term “axial direction”, “axial”, or “axially”, radial directions around the motor axis J**2** will be simply referred to by the term “radial direction”, “radial”, or “radially”, and a circumferential direction around the motor axis J**2**, that is, a circumferential direction about the motor axis J**2**, will be simply referred to by the term “circumferential direction”, “circumferential”, or “circumferentially”. However, the term “parallel” as used above includes both “parallel” and “substantially parallel”.

[0016] The motor unit **1** of the present embodiment is mounted on a vehicle using a motor as a power source, such as a hybrid electric vehicle (HEV), a plug-in hybrid electric vehicle (PHV), or an electric vehicle (EV), and is used as the power source.

[0017] As illustrated in FIG. **1**, the motor unit **1** includes the motor **2**, a transmission mechanism **3**, a housing **6**, oil O accommodated in the housing **6**, an oil cooler **9**, and an inverter device **110**.

[0018] The motor **2** includes a rotor **20** that rotates about the motor axis J**2** extending in the horizontal direction, and a stator **30** located radially outside the rotor **20**.

[0019] The housing **6** includes a motor housing **60** that accommodates the motor **2**, a motor cover **61** that closes an end part on one side (−Y side) of the motor housing **60**, and a gear housing **62** that is located at an end part on the other side (+Y side) of the motor housing **60** and accommodates the transmission mechanism **3**.

[0020] The motor **2** is an inner rotor type motor. The rotor **20** is arranged radially inside the stator **30**. The rotor **20** includes a shaft **21**, a rotor core **24**, and a rotor magnet (not illustrated). The motor **2** may be an outer rotor type motor.

[0021] The shaft **21** is arranged about the motor axis J2 extending in a horizontal direction and in a width direction of a vehicle. The shaft **21** is a hollow shaft having a hollow part **22** inside. The shaft **21** protrudes from the motor housing **60** into the gear housing **62**. An end part of the shaft **21** protruding to the gear housing **62** is coupled to the transmission mechanism **3**. Specifically, the shaft **21** is coupled to a first gear **41** of the transmission mechanism **3**.

[0022] The stator **30** encloses the rotor **20** from radially outside. The stator **30** includes a stator core **32**, a coil **31**, and an insulator (not illustrated) interposed between the stator core **32** and the coil **31**. The stator **30** is held by the motor housing **60**. The coil **31** is connected to the inverter device **110** directly or via a bus bar (not illustrated).

[0023] The transmission mechanism **3** is accommodated in the gear housing **62**. The transmission mechanism **3** is connected to the shaft **21** on one side in the axial direction of the motor axis J2. The transmission mechanism **3** includes a reduction gear **4** and a differential gear **5**. Torque output from the motor **2** is transmitted to the differential gear **5** through the reduction gear **4**.

[0024] The reduction gear **4** is connected to the shaft **21** of the motor **2**. The reduction gear **4** has the first gear **41**, a second gear **42**, a third gear **43**, and an intermediate shaft **45**. The first gear **41** is coupled to the shaft **21** of the motor **2**. The intermediate shaft **45** extends along an intermediate axis J4 parallel to the motor axis J2. The second gear **42** and the third gear **43** are fixed to both ends of the intermediate shaft **45**. The second gear **42** and the third gear **43** are connected to each other via the intermediate shaft **45**. The second gear **42** meshes with the first gear **41**. The third gear **43** meshes with a ring gear **51** of the differential gear **5**.

[0025] Torque output from the motor **2** is transmitted to the ring gear **51** of the differential gear **5** through the shaft **21** of the motor **2**, the first gear **41**, the second gear **42**, the intermediate shaft **45**, and the third gear **43**. A gear ratio of each gear, the number of gears, and the like can be modified in various manners in accordance with a required reduction ratio. The reduction gear **4** is a speed reducer of a parallel-axis gearing type, in which axis centers of gears are arranged in parallel with one another.

[0026] The differential gear **5** transmits torque output from the motor **2** to an axle of a vehicle. The differential gear **5** transmits the torque to axles **55** of both the left and right wheels while absorbing the speed difference between the left and right wheels when the vehicle turns. The differential gear **5** includes a gear housing, a pinion gear, a pinion shaft, and a side gear (all not illustrated) in addition to the ring gear **51** meshing with the third gear of the reduction gear **4**.

[0027] A lower region in the gear housing **62** is provided with an oil reservoir P in which the oil O accumulates. In the present embodiment, a bottom part of the motor housing **60** is located at a higher level than a bottom part of the gear housing **62**. With this configuration, the oil O after the motor **2** is cooled can be easily collected from a lower region of the motor housing **60** to the oil reservoir P of the gear housing **62**.

[0028] A part of the differential gear **5** soaks in the oil reservoir P. The oil O accumulated in the oil reservoir P is scraped up by operation of the differential gear **5**. A part of the scraped oil O is supplied into the shaft **21**. Another part of the oil O is diffused into the gear housing **62** and supplied to each gear of the reduction gear **4** and the differential gear **5**. The oil O used for lubrication of the reduction gear **4** and the differential gear **5** is dropped and collected in the oil reservoir P located on the lower side of the gear housing **62**.

[0029] The inverter device **110** includes an inverter **110*a*** electrically connected to the motor **2** and an inverter case **120** accommodating the inverter **110*a***. The inverter **110*a*** controls current to be supplied to the motor **2**. The inverter case **120** is fixed to the motor housing **60**. A cooling water pipe **95** extending from a radiator of the vehicle is connected to the inverter device **110**. The cooling water pipe **95** extends to the oil cooler **9** via the inverter device **110**.

[0030] The oil cooler **9** is located on a side surface of the motor housing **60**. The cooling water pipe **95** extending from the inverter device **110** is connected to the oil cooler **9**. The oil **0** discharged from an electric oil pump **10** is supplied to the oil cooler **9**. The oil O passing through the inside of the oil cooler **9** is cooled through heat exchange with cooling water passing through the cooling water pipe **95**.

[0031] The oil O cooled by the oil cooler **9** is supplied to the motor **2**.

[0032] The electric oil pump **10** is an oil pump driven by a pump motor **10*a***. The electric oil pump **10** sucks up the oil O from the oil reservoir P and supplies the oil O to the oil cooler **9**. The pump motor **10*a*** rotates a pump mechanism of the electric oil pump **10**. In the motor unit **1**, a rotation axis J6 of the pump motor **10*a*** is parallel to the motor axis J2. The electric oil pump **10** having the pump motor **10*a*** tends to become long in a direction in which the rotation axis J6 extends. By making the rotation axis J6 of the pump motor **10*a*** parallel to the motor axis J2, the electric oil pump **10** becomes less likely to protrude in the radial direction of the motor unit **1**. This makes it possible to reduce the radial dimension of the motor unit **1**.

[0033] As illustrated in FIG. **1**, the oil O circulates in an oil passage **90** provided in the housing **6**. The oil passage **90** is a path of the oil O for supplying the oil O from the oil reservoir P to the motor **2**.

[0034] The oil O circulating in the oil passage **90** is used as lubricating oil for the reduction gear **4** and the differential gear **5** and as cooling oil for the motor **2**. The oil O accumulates in the oil reservoir P in a lower part of the gear housing **62**. Oil equivalent to automatic transmission fluid (ATF) having a low viscosity is preferably used as the oil O so that the oil O can perform functions of lubricating oil and cooling oil.

[0035] As illustrated in FIG. **1**, the oil passage **90** is a path of the oil O that is guided from the oil reservoir Pon the lower side of the motor **2** to the oil reservoir P on the lower side of the motor **2** again via the motor **2**. The oil passage **90** includes a first oil passage **91** passing through the inside of the motor **2** and a second oil passage **92** passing through the outside of the motor **2**. The oil O cools the motor **2** from the inside and the outside through the first oil passage **91** and the second oil passage **92**.

[0036] The oil O is scraped up by the differential gear **5** from the oil reservoir P, and is guided into an interior of the rotor **20** through the first oil passage **91**. The oil O is sprayed from the rotor **20** toward the coil **31** to cool the stator **30**. The oil **0** having cooled the stator **30** moves to the oil reservoir P of the gear housing **62** via the lower region of the motor housing **60**.

[0037] In the second oil passage **92**, the oil O is pumped up from the oil reservoir P by the electric oil pump **10**. The oil O is pumped up to an upper part of the motor **2** via the oil cooler **9** and is supplied to the motor **2** from the upper side of the motor **2**. The oil O having cooled the motor **2** moves to the oil reservoir P of the gear housing **62** via the lower region of the motor housing **60**.

[0038] As illustrated in FIGS. **1** to **3**, the inverter device **110** includes the inverter **110***a* and the inverter case **120** accommodating the inverter **110***a* inside the inverter case **120**. The inverter case **120** includes a box-shaped case body **121** that opens upward, and a cover **122** that closes an opening of the case body **121** from above.

[0039] As illustrated in FIG. **2**, the case body **121** is continuous to the outer peripheral surface of the motor housing **60**. The case body **121** is located on the vehicle front side (+X side) of the motor housing **60**. In the motor unit **1**, the case body **121** and the motor housing **60** are a part of a single die casting member.

[0040] The cover **122** is a plate-like member that covers the inverter **110***a* from above. The cover **122** constitutes a top wall of the inverter case **120**. In the present embodiment, the inverter case **120** has a configuration including the box-shaped case body **121** that opens upward and the plate-shaped cover **122**, but other configurations can be adopted. For example, a configuration in which the case body **121** is opened in the axial direction (Y-axis direction), a configuration in which the case body **121** is opened to the vehicle front side (+X side), or a configuration in which the case body **121** is opened to the lower side (-Z side) maybe adopted. In these cases, the wall located at the upper end of the case body **121** is a top wall covering the inverter **110***a* from above.

[0041] In the present embodiment, the inverter **110***a* is fixed to the lower surface of the cover **122** as illustrated in FIG. **3**. According to this configuration, since the cover **122** and the inverter **110***a* can be unitized, the manufacturing process can be made efficient. The inverter device **110** may have a configuration in which the inverter **110***a* is fixed to the case body **121**.

[0042] As illustrated in FIGS. **2** to **4**, the cover **122** has a first inclined surface **131** descending from a top part **130** on the upper surface of the cover **122** toward a first end part **122***a* of the cover **122**, and a second inclined surface **132** descending from the top part **130** toward a second end part **122***b* different from the first end part **122***a*.

[0043] The first end part **122***a* of the cover **122** is an end part on the vehicle rear side (−X side) in the motor unit **1**. The second end part **122***b* is an end part on the vehicle front side (+X side) of the motor unit **1**. The top part **130** is located midway between the first end part **122***a* and the second end part **122***b* in the vehicle front-rear direction (X-axis direction).

[0044] The top part **130** is a belt-shaped region extending along the vehicle left-right direction (Y-axis direction) when the motor unit **1** is viewed from above. From both end parts in the width direction of the top part **130**, the first inclined surface **131** and the second inclined surface **132** expand toward the first end part **122***a* and the second end part **122***b*, respectively. In the present embodiment, the top part **130** is a topmost part located at the uppermost side on the upper surface of the cover **122**. The top part **130** may exist at a plurality of places on the upper surface of the cover **122**.

[0045] The top part **130** means an upper end part of a planar part facing upward in the upper surface of the cover **122**, and does not include a site locally protruding from the upper surface of the cover **122**. Examples of the site locally protruding from the upper surface of the cover **122** include a screw fixing boss, a screw head, or a first rod-shaped rib **141**, a second rod-shaped rib **142**, a first coupling rib **151**, and a second coupling rib **152**, which will be described later.

[0046] The first inclined surface **131** and the second inclined surface **132** may be inclined toward end parts of the cover **122** different from each other. The inclination direction of the first inclined surface **131** and the inclination direction of the second inclined surface **132** maybe directions that are parallel to each other or may be directions that intersect each other. For example, the inclination direction of the first inclined surface **131** and the inclination direction of the second inclined surface **132** may be configured to be orthogonal to each other.

[0047] The cover **122** has a plurality of the first rod-shaped ribs **141** extending from the top part **130** toward the first end part **122***a*. As illustrated in FIGS. **3** and **6**, the first rod-shaped rib **141** has a site where a protrusion height from the first inclined surface **131** increases toward the first end part **122***a*.

[0048] The cover **122** has a plurality of the second rod-shaped ribs **142** extending from the top part **130** toward the second end part **122***b*. The second rod-shaped rib **142** has a site where a protrusion height from the second inclined surface **132** increases toward the second end part **122***b*.

[0049] According to the above configuration, since both the first inclined surface **131** and the second inclined surface **132** of the cover **122** go down from the top part **130** toward the end part of the cover **122**, even when water falls on the upper surface of the inverter device **110**, the water on the upper surface of the cover **122** flows down along the first inclined surface **131** or the second inclined surface **132** to the first end part **122***a* or the second end part **122***b*. This makes it difficult for water to accumulate on the inverter device **110**.

[0050] Since the first rod-shaped rib **141** extends along the first inclined surface **131** and the second rod-shaped rib **142** extends along the second inclined surface **132**, water flowing on the first inclined surface **131** and the second inclined surface **132** smoothly flows to the end part of the cover **122** without being obstructed by the first rod-shaped rib **141** and the second rod-shaped rib **142**, and is discharged to the outside of the cover **122**.

[0051] Since the first inclined surface **131** and the second inclined surface **132** have the first rod-shaped rib **141** and the second rod-shaped rib **142**, membrane resonance is suppressed on both of the first inclined surface **131** and the second inclined surface **132**. Therefore, generation of noise in the motor unit **1** can be suppressed.

[0052] The protrusion height of the first rod-shaped rib **141** from the first inclined surface **131** increases toward the first end part **122***a*, and the protrusion height of the second rod-shaped rib **142** from the second inclined surface **132** increases toward the second end part **122***b*. According to this configuration, since the protrusion heights of the first rod-shaped rib **141** and the second rod-shaped rib **142** in the vicinity of the top part **130** are suppressed, it is possible to suppress the thickness of the cover **-122** from becoming excessively large. On the other hand, since the first rod-shaped rib **141** and the second rod-shaped rib **142** can secure the required protrusion height at the end part of the cover **122**, it is easy to secure the rigidity with which the noise suppression effect can be obtained.

[0053] In the present embodiment, both the first rod-shaped rib **141** and the second rod-shaped rib **142** are configured to extend in the vehicle front-rear direction (X-axis direction), but any one or both of the first rod-shaped rib **141** and the second rod-shaped rib **142** may be configured to extend in a direction intersecting the vehicle front-rear direction (X-axis direction).

[0054] As in the present embodiment, when the direction from the top part **130** toward the first end part **122***a* is the vehicle front-rear direction, the direction in which the first rod-shaped rib **141** extends can be a direction intersecting the vehicle front-rear direction within a range of less than ±45°. The same applies to the second rod-shaped rib **142**. By setting the intersection angle to the above range, it is possible to suppress the flow of water along the first inclined surface **131** and the second inclined surface **132** from being obstructed by the first rod-shaped rib **141** and the second rod-shaped rib **142**.

[0055] In the present embodiment, the cover **122** is configured to have the first inclined surface **131** and the second inclined surface **132**, but the cover **122** may be configured to only have any one of the first inclined surface **131** and the second inclined surface **132**. For example, even in a case where the cover **122** has only the first inclined surface **131**, the water having fallen on the upper surface of the inverter device **110** flows down on the first inclined surface **131** located between the plurality of first rod-shaped ribs **141** from the top part **130** toward the first end part **122***a*. This makes it possible to suppress water from accumulating on the upper surface of the inverter device **110**.

[0056] The cover **122** may be configured to have three or more inclined surfaces. Also in this case, by making the three or more inclined surfaces inclined surfaces descending from the top part **130** toward the peripheral edge part of the cover **122**, it is possible to achieve a configuration in which water is less likely to accumulate on the upper surface of the cover **122**.

[0057] The cover **122** has a plurality of the first coupling ribs **151** that couple two of the first rod-shaped ribs **141** arranged next to each other . In the case of the present embodiment, two or three of the first coupling ribs **151** are bridged between the two of the first rod-shaped ribs **141** arranged next to each other.

[0058] According to this configuration, the plurality of first coupling ribs **151** can reinforce the plurality of first rod-shaped ribs **141**. Membrane vibration of the first inclined surface **131** can be further suppressed by improving the strength of the rib supporting the first inclined surface **131**. Noise caused by membrane resonance of the first inclined surface **131** can be reduced.

[0059] In the cover **122**, as illustrated in FIG. **3**, the individual first coupling ribs **151** have a protrusion height of a side surface **151***a* facing the top part **130** side from the first inclined surface **131** that is smaller than a protrusion height of a side surface **151***b* facing the first end part **122***a* side from the first inclined surface **131**.

[0060] According to this configuration, when water flows from the top part **130** side with respect to the first coupling rib **151**, since the side surface **151***a* on the top part **130** side is low, the water easily gets over the first coupling rib **151**. Therefore, it is possible to provide the inverter device **110** in which water is less likely to accumulate on the upper surface of the cover **122**.

[0061] An upper surface **151***c* of the first coupling rib **151** is preferably a flat surface expanding in the horizontal direction or a flat surface having an inclination of equal to or less than 10° with respect to the horizontal direction. According to this configuration, it becomes possible to easily secure the height of the first coupling rib **151** while causing water to easily flow on the first inclined surface **131**. It becomes easy to secure the rigidity of the first coupling rib **151**.

[0062] The upper surface **151***c* may be an inclined surface descending toward the first end part **122***a*. According to this configuration, the water having flown onto the upper surface **151***c* easily flows to the first end part **122***a* side.

[0063] The cover **122** may have a coupling rib also on the second inclined surface **132** similar to that on the first inclined surface **131** side. That is, as illustrated in FIGS. **3** and **4**, the cover **122** may be configured to have the plurality of second coupling ribs **152** that couple two of the second rod-shaped ribs **142** arranged next to each other, and the individual second coupling ribs **152** may have a configuration in which a protrusion height of a side surface facing the top part **130** side from the second inclined surface is smaller than a protrusion height of a side surface facing the second end part **122***b* side from the second inclined surface. According to this configuration, the strength of the ribs can be increased even on the second inclined surface **132**. Membrane resonance is less likely to occur on the second inclined surface **132**, and noise is reduced.

[0064] As illustrated in FIGS. **3** and **4**, the cover **122** has a honeycomb-shaped lower surface rib **161** on the lower surface of the cover **122**. The lower surface rib **161** has a configuration in which regular hexagonal annular ribs are arranged without a gap on the lower surface of the cover **122**. The honeycomb-shaped lower surface rib **161** is excellent in flexural strength and compressive strength as compared with other polygonal ribs. Therefore, by providing the cover **122** with the honeycomb-shaped lower surface rib **161**, it is possible to increase the rigidity of the cover **122**, and it is possible to provide a thin, low-noise cover.

[0065] As illustrated in FIGS. **3** and **5**, the cover **122** has a first back side inclined surface **171** following the first inclined surface **131** on the back side of the first inclined surface **131**. As illustrated in FIG. **3**, the lower surface rib **161** located on the first back side inclined surface **171** has a larger protrusion height downward from the first back side inclined surface **171** toward the top part **130**.

[0066] On the upper surface of the cover **122**, the first rod-shaped rib **141** has a small protrusion height in the vicinity of the top part **130**. By making the protrusion height of the lower surface rib **161** relatively high in the vicinity of the top part **130**, it becomes easily to secure the rigidity of the entire top part **130**. Since the protrusion height of the first rod-shaped rib **141** can be reduced in the vicinity of the top part **130**, the upper surface of the inverter device **110** can be easily flattened, so that a space with components located around the motor unit **1** can be easily secured in the vehicle.

[0067] As illustrated in FIGS. **3** to **5**, the cover **122** has through holes **124** and **125** penetrating the cover **122** in the up-down direction. The through hole **124** and the through hole **125** are, for example, access ports into which a tool for electrically connecting the inverter **110***a* and the stator **30** of the motor **2** is inserted.

[0068] As illustrated in FIGS. **3** and **5**, the cover **122** has a trapezoidal lower surface rib **162** located in the vicinity of the through holes **124** and **125** in the lower surface of the cover **122**. The lower surface rib **162** of the present embodiment has a configuration in which a plurality of trapezoidal annular ribs are arranged without a gap on the lower surface of the cover **122**. The lower surface rib **162** is located in a region surrounded by the through hole **124** and the through hole **125** and the outer peripheral edge of the cover **122**.

[0069] In the present embodiment, the "trapezoidal rib" is not limited to a geometrically accurate trapezoidal annular rib. The "trapezoidal rib" of the present embodiment may be an annular rib including at least two linear ribs parallel to each other and at least one linear rib bridged between the two linear ribs.

[0070] As illustrated in FIG. **5**, the lower surface rib **162** includes more linear ribs than that of the honeycomb-shaped lower surface rib **161**. According to the lower surface rib **162**, it is easy to obtain higher rigidity than the honeycomb-shaped lower surface rib **161**. In the cover **122**, the sites where the through holes **124** and **125** are provided is liable to decrease in rigidity, and therefore, by arranging the trapezoidal lower surface rib **162** in the vicinity of the through holes **124** and **125**, it becomes easy to secure the rigidity of the cover **122**.

[0071] The shape of the lower surface rib **162** can also be described as a shape in which two vertices of the honeycomb-shaped rib are connected by a linear rib passing through the inside of the hexagon. By having the linear rib connecting the vertices of the honeycomb, the area of the region surrounded by the rib is smaller and the installation density of the ribs becomes larger than those of a simple honeycomb-shaped rib. This increase the rigidity of the lower surface rib **162**, and increases the noise reduction effect by the lower surface rib **162**.

[0072] As illustrated in FIG. **3**, the cover **122** has a second back side inclined surface **172** following the second inclined surface **132** on the back side of the second inclined surface **132**. The lower surface rib **162** located on the second back side inclined surface **172** has a larger protrusion height from the second back side inclined surface **172** toward the top part **130**.

[0073] Also on the second inclined surface **132**, since the protrusion height of the second rod-shaped rib **142** is relatively low in the vicinity of the top part **130**, the rigidity of the entire top part **130** can be easily secured by making the protrusion height of the lower surface rib **162** relatively high in the vicinity of the top part **130**. Since the protrusion height of the second rod-shaped rib **142** can be reduced in the vicinity of the top part **130**, the upper surface of the inverter device **110** can be easily flattened, so that a space with components located around the motor unit **1** can be easily secured in the vehicle.

[0074] The cover **122** has a refrigerant flow path **123** in a central part when the cover **122** is viewed from below. The cooling water pipe **95** illustrated in FIG. **1** is connected to the refrigerant flow path **123**. The inverter **110***a* attached to the lower surface of the cover **122** is cooled by the cooling water flowing through the refrigerant flow path **123**. The cover **122** may be configured not to include the refrigerant flow path **123**.

[0075] In the above embodiment, the motor unit **1** including the motor **2**, the transmission mechanism **3**, and the inverter device **110** has been described, but the motor unit **1** may be configured to include only the motor **2** and the inverter device **110**.

[0076] That is, the embodiment of the present invention can also be configured as a motor including the rotor **20**, the stator **30**, the motor housing **60** that accommodates the rotor **20** and the stator **30**, and the inverter device **110** arranged in contact with the motor housing **60**.

[0077] In the motor, the motor housing **60** and the inverter case **120** may be a part of a single die casting member similarly to the previous embodiment. Alternatively, the motor housing **60** and the inverter case **120** formed of separate members from each other may be included. Even if the inverter case **120** and the motor housing **60** are separate components, when they are arranged in contact with each other, vibration of the motor is transmitted to the inverter case **120**. Since the inverter device **110** includes the cover **112** of the embodiment, vibration of the inverter case **120** can be suppressed, and a puddle on the upper surface is less likely to occur.

[0078] Features of the above-described preferred embodiments and the modifications thereof may be combined appropriately as long as no conflict arises.

[0079] While preferred embodiments of the present disclosure have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present disclosure. The scope of the present disclosure, therefore, is to be determined solely by the following claims.

1. An inverter device comprising:
an inverter; and
an inverter case that accommodates the inverter inside the inverter case,
wherein the inverter case has a top wall covering the inverter from above,
the top wall includes
a first inclined surface descending from a top part on an upper surface of the top wall toward a first end part of the top wall, and
a plurality of first rod-shaped ribs extending from the top part toward the first end part, and
the first rod-shaped rib has a site in which a protrusion height from the inclined surface increases toward the first end part.

2. The inverter device according to claim **1**, comprising
a plurality of first coupling ribs coupling two of the first rod-shaped ribs arranged next to each other,
wherein each of the first coupling ribs has a protrusion height of a side surface facing a top part side from the first inclined surface that is smaller than a protrusion height of a side surface facing a first end part side from the first inclined surface.

3. The inverter device according to claim **1**, wherein
the top wall includes
a second inclined surface descending from the top part toward a second end part different from the first end part, and
a plurality of second rod-shaped ribs extending from the top part toward the second end part, and
the second rod-shaped rib has a site in which a protrusion height from the inclined surface increases toward the second end part.

4. The inverter device according to claim **3**, comprising a plurality of second coupling ribs coupling two of the second rod-shaped ribs arranged next to each other,
wherein each of the second coupling ribs has a protrusion height of a side surface facing a top part side from the second inclined surface that is smaller than a protrusion

height of a side surface facing a second end part side from the second inclined surface.

5. The inverter device according to claim **2**, wherein an upper surface of the coupling rib is a flat surface expanding in a horizontal direction or a flat surface having an inclination of equal to or less than 10° with respect to the horizontal direction.

6. The inverter device according to claim **1**, wherein the top wall includes a honeycomb-shaped lower surface rib on a lower surface of the top wall.

7. The inverter device according to claim **1**, wherein

the top wall includes

a through hole penetrating the top wall in an up-down direction, and

a lower surface rib located in a vicinity of the through hole on the lower surface of the top wall.

8. The inverter device according to claim **7**, wherein the lower surface rib located in the vicinity of the through hole has a shape in which two vertices of a honeycomb-shaped rib are connected by a linear rib passing through an inside of a hexagon.

9. The inverter device according to claim **6**, wherein

the top wall has a first back side inclined surface following the first inclined surface on a back side of the first inclined surface, and

the lower surface rib located on the first back side inclined surface has a site where a protrusion height from the first back side inclined surface increases toward the top part.

10. The inverter device according to claim **6**, wherein

the top wall has a second inclined surface descending from the top part toward a second end part different from the first end part, and

the top wall has a second back side inclined surface following the second inclined surface on a back side of the second inclined surface, and the lower surface rib located on the second back side inclined surface has a site where a protrusion height from the second back side inclined surface increases toward the top part.

11. A motor comprising:

a rotor and a stator;

a motor housing that accommodates the rotor and the stator; and

the inverter device according to claim **1** arranged in contact with the motor housing.

12. The motor according to claim **11**, wherein the inverter case and the motor housing have a site formed of a common single member.

13. A motor unit comprising:

the motor according to claim **11**; and

a transmission mechanism that couples the motor and an axle.

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